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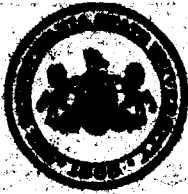
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THE PENNSYLVANIA  
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# IONOSPHERIC RESEARCH

Scientific Report 437

## F-REGION DRIFT VELOCITIES FROM INCOHERENT-SCATTER MEASUREMENTS AT MILLSTONE HILL

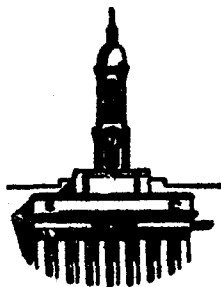
by

Lynn A. Carpenter and Volker W. J. H. Kirchhoff

October 17, 1975

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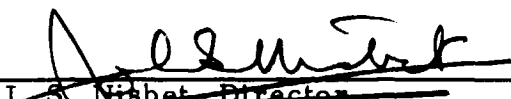
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## ABSTRACT

F-region drift velocities measured at Millstone Hill from 1968 to 1974 are presented in tabular form. A brief description of the measurement procedures is also given.

The Millstone Hill incoherent scatter radar is located in Westford, Massachusetts. Relevant coordinate parameters are:

Geographic latitude	42.6°N
Geographic longitude	71.5°W
Geomagnetic latitude <sup>1</sup>	54.1°N
Geomagnetic longitude	1.9°W
L value <sup>2</sup>	3.2
Inclination or dip angle	72.0°
Declination	15.0°W
Invariant latitude <sup>3</sup> ( $\Lambda$ )	56.0°N
Dip latitude <sup>4</sup> ( $\theta$ )	57.0°N

<sup>1</sup>Calculated from geographic coordinates, assuming magnetic axis tilted by 11.5° at 70.0°W.

<sup>2</sup>From map in Matsushita and Campbell (1967).

<sup>3</sup>Calculated from  $\cos^2 \Lambda = 1/L$ .

<sup>4</sup>Calculated from  $\tan \theta \approx 1/2 \tan I$ .

At Millstone Hill, one fixed vertically pointing antenna with a parabolic reflector of diameter 67.5 m is available for operation at UHF ( $\lambda = 68$  cm), and one steerable antenna, 25.6 m in diameter operates at L band ( $\lambda = 23.2$  cm). Further details on the equipment are given by Evans (1967) and Evans et al., (1970a).

Basically four different geometries have been used at Millstone Hill for the measurements of ionospheric plasma drift velocities and these are briefly described below.

Geometry I. This was the first procedure followed to measure ionospheric drifts. It uses only the UHF vertical antenna and therefore measures only vertical drifts (see Evans et al., 1970).

Geometry II. This antenna positioning procedure was used by Evans (1972) and uses only the L band steerable antenna at small elevation angles to measure nearly horizontal drift velocity components.

Geometry III. This uses both L band and UHF antennas combining geometries I and II (Carpenter and Kirchhoff, 1974). Vertical drift velocities as well as electron density, electron and ion temperatures, are measured with the vertically pointing fixed antenna. The steerable antenna is then used to measure the horizontal components of drift velocity. In this way three-dimensional drift vectors can be deduced, and diffusion velocities and meridional neutral winds can be calculated. Because of these features this is the most versatile geometry for drift velocity measurements. However, since the radar is monostatic, the measurements in different directions do not apply to the same volume of ionospheric plasma.

Geometry IV. In a proposal for upgrading the Millstone Hill radar for the International Magnetosphere Studies (IMS), Evans (1974) proposes to use the L band antenna alone, pointing sequentially east and west of magnetic north at elevation and azimuth angles such that two drift velocities perpendicular to the magnetic field can be measured at the same L value. Different azimuth and elevation angles allow these drifts to be measured at different L values.

The first measurement of drift velocities perpendicular to the magnetic field lines at Millstone Hill was made by Evans (1972), during the daytime, and his results for 9 days in 1968-69 will be included as

part of this data base. As mentioned earlier geometry II was used for these measurements. The 1971-72 data consists of either northward or westward drifts only. For the period 1973-74 either geometry III or IV was used, thus permitting the calculation of neutral winds.

The drift velocities in the F-region have been shown to be approximately constant with height (Evans, 1972) so that measurements between about 200 and 400 km are in general averaged and referred to an average altitude of 300 km. Local standard time (GMT - 5 hrs.) is used.

Since the conductivity along magnetic field lines is very large, the ionospheric electric field is practically perpendicular to the magnetic field lines and therefore the components of the drifts are separated into westward (horizontal) and northward (at  $18^\circ$  elevation). The uncertainties in the measurements have been studied by Evans et al., (1970), and Kirchhoff (1975).

## SUMMARY

### LIST OF MILLSTONE HILL MEASUREMENTS

Drift velocities measured at Millstone Hill are shown in the following tables. Directions are magnetic northward at  $18^{\circ}$  elevation angle and magnetic westward. Results are in m/sec versus local standard time (i. e. GMT - 5 hrs.). The data for 1968/69 is from Evans (1972), interpolated for hourly values. The other data was taken by L. Carpenter and V. Kirchhoff with the assistance of the Millstone Hill staff.

Table 1 21 NOV 68 and 10 DEC 68, north and westward velocities

Northward		Westward	
Date = 21 NOV 68		Date = 10 DEC 68	
Day Number = 326		Day Number = 345	
Drift Velocities		Drift Velocities	
ΣKp = 12.33		ΣKp = 21	
F10.7 = 137.1		F10.7 = 152.6	
F10.7 = 146.4		F10.7 = 146.5	
Local Time (hr:min)	Velocity (m/sec)	Local Time (hr:min)	Velocity (m/sec)
09:00	-25	09:00	-12
10:00	32	10:00	-16
11:00	26	11:00	-22
12:00	32	12:00	-35
13:00	12	13:00	-44
14:00	6	14:00	-34
15:00	-23	15:00	7
16:00	-14	16:00	31
17:00	17	17:00	18
18:00	-3	18:00	10
		19:00	8
Date = 10 DEC 68		Date = 10 DEC 68	
Day Number = 345		Day Number = 345	
ΣKp = 21		ΣKp = 21	
F10.7 = 152.6		F10.7 = 152.6	
F10.7 = 146.5		F10.7 = 146.5	
Local Time (hr:min)	Velocity (m/sec)	Local Time (hr:min)	Velocity (m/sec)
10:00	6	10:00	-20
11:00	4	11:00	-32
12:00	1	12:00	-47
13:00	-1	13:00	-33
14:00	-8	14:00	-31
15:00	-12	15:00	-4
16:00	-9	16:00	-13
17:00	-12	17:00	-32
18:00	-16	18:00	8

Table 2 22 JAN 69 and 17 APR 69, north and westward velocities

Table 2 Drift Velocities				
Date = 22 JAN 69	Day Number = 22	$\Sigma Kp = 7$	$F10.7 = 138.2$	$\bar{F} 10.7 = 152.1$
Northward		Westward		
Local Time (hr:min)	Velocity (m/sec)	Local Time (hr:min)	Velocity (m/sec)	
10:00	17	10:00	-4	
11:00	14	11:00	-10	
12:00	10	12:00	-16	
13:00	-4	13:00	-23	
14:00	-2	14:00	-28	
15:00	-4	15:00	-20	
16:00	-26	16:00	-16	
17:00	-2	17:00	-5	
18:00	-8	18:00	5	
19:00	-6	19:00	7	
20:00	-15	20:00	13	
Date = 17 APR 69 Day Number=107 $\Sigma Kp = 28.33$ $F10.7 = 153.5$ $\bar{F} 10.7 = 157.7$				
07:00	3	08:00	11	
08:00	23	09:00	-8	
09:00	26	10:00	-47	
10:00	64	11:00	-78	
11:00	35	12:00	-37	
12:00	33	13:00	-69	
13:00	43	14:00	-36	
14:00	10	15:00	-24	
15:00	-28	16:00	21	
16:00	-26	17:00	36	
17:00	-2	18:00	101	
18:00	13			

Table 3 14 MAY 69 and 10 JUN 69, north and westward velocities

Table 3			Drift Velocities	
Date = 14 MAY 69		Day Number = 134	$\Sigma Kp = 50$	$F10.7 = 154.3$ $\bar{F} 10.7 = 154.4$
Northward		Westward		
Local Time (hr:min)	Velocity (m/sec)	Local Time (hr:min)	Velocity (m/sec)	
07:00	-11	07:00	18	
08:00	1	08:00	11	
09:00	30	09:00	-9	
10:00	11	10:00	-37	
11:00	-15	11:00	-24	
12:00	-10	12:00	-20	
13:00	-9	13:00	-33	
14:00	18	14:00	3	
15:00	25	15:00	146	
16:00	19	16:00	187	
17:00	-9			

Date = 10 JUN 69		Day Number = 161	$\Sigma Kp = 15.66$	$F10.7 = 236.2$ $\bar{F} 10.7 = 148.1$
07:00	6	07:00	28	
08:00	3	08:00	23	
09:00	5	09:00	12	
10:00	10	10:00	-5	
11:00	16	11:00	-32	
12:00	17	12:00	-49	
13:00	-36	13:00	-18	
14:00	-32	14:00	-10	
15:00	-19	15:00	-14	
16:00	-2	16:00	9	
17:00	-3	17:00	15	
18:00	-19	18:00	13	



Table 4 16 JUL 69 and 20 AUG 69, north and westward velocities

Table 4 Date = 16 JUL 69    Day Number = 197 $\Sigma Kp = 18.33$ Drift Velocities $F10.7 = 122.1$ $\bar{F}10.7 = 147.3$			
Northward		Westward	
Local Time (hr:min)	Velocity (m/sec)	Local Time (hr:min)	Velocity (m/sec)
07:00	-22	07:00	38
08:00	-7	08:00	42
09:00	-9	09:00	-20
10:00	2	10:00	-2
11:00	-8	11:00	-15
12:00	-29	12:00	10
13:00	-33	13:00	14
14:00	-20	14:00	7
Date = 20 AUG 69    Day Number = 232 $\Sigma Kp = 6$ $F10.7 = 106.9$ $\bar{F}10.7 = 139.0$			
07:00	24	07:00	16
08:00	15	08:00	0
09:00	8	09:00	-13
10:00	-10	10:00	-25
11:00	0	11:00	-35
12:00	-21	12:00	-42
13:00	-23	13:00	-37
14:00	-16	14:00	11
15:00	-26	15:00	17
16:00	-22	16:00	-25
17:00	-24	17:00	-6
		18:00	-5

Table 5 19 SEP 69 and 6 SEP 72, northward velocities

Table 5		Drift Velocities	
Date = 19 SEP 69		Day Number = 262	
$\Sigma Kp = 9$		$F10.7 = 130.3$	
		$\bar{F}10.7 = 144.8$	
Northward		Westward	
Local Time (hr:min)	Velocity (m/sec)	Local Time (hr:min)	Velocity (m/sec)
08:00	23	08:00	-16
09:00	27	09:00	-27
10:00	23	10:00	-35
11:00	21	11:00	-38
12:00	16	12:00	-34
13:00	-7	13:00	-31
14:00	-10	14:00	-18
15:00	-20	15:00	-7
16:00	-14	16:00	3
17:00	-16	17:00	-3
18:00	-5	18:00	-6

Table 6 19 SEP 69 and 26 JUL 72, westward velocities

Table 6		Drift Velocities	
Date = 19 SEP 69		Day Number = 262	
$\Sigma Kp = 9$		$F10.7 = 130.3$	
		$\bar{F}10.7 = 144.8$	
Northward		Westward	
Local Time (hr:min)	Velocity (m/sec)	Local Time (hr:min)	Velocity (m/sec)
08:00	29	11:00	-21
09:00	9	12:00	-25
10:00	-9	13:00	-13
11:00	0	14:00	3
12:00	-20	15:00	13
13:00	-4	16:00	9
14:00	0	17:00	34
15:00	-9	18:00	32
16:00	-3	19:00	54
17:00	-13	20:00	55
18:00	5	21:00	66
19:00	6	22:00	84
20:00	-5	23:00	104

Table 7 30 MAY 72, northward velocity

Table 7		Table 8	
Drift Velocities		Drift Velocities	
Date = 30 MAY 72		Date = 30 JUN 72	
Day Number = 151		Day Number = 182	
$\Sigma Kp = 22.33$		$\Sigma Kp = 6.33$	
$F10.7 = 113.6$		$F10.7 = 130.1$	
$\bar{F}10.7 = 126.0$		$\bar{F}10.7 = 129.0$	
Northward		Northward	
Local Time (hr:min)	Velocity (m/sec)	Local Time (hr:min)	Velocity (m/sec)
07:00	0	13:00	5
08:00	2	14:00	2
09:00	5	15:00	9
10:00	15	16:00	0
11:00	7	17:00	-9
12:00	-12	18:00	-10
13:00	-29	19:00	-19
14:00	0	20:00	-1
15:00	10	21:00	-4
16:00	3	21:30	9
17:00	-12	23:00	-5
18:00	-11	00:08	-1
19:00	12	01:00	-25
20:00	52	03:00	-15
21:00	90	04:00	-39
22:00	80	05:00	-20
		06:00	-18
		07:00	-12
		08:00	-11
		09:00	-10
		10:00	1
		11:00	-5
		12:00	2

Table 8 30 JUN 72, northward velocity

Table 9 15 NOV 72 and 27 JAN 72,  
northward velocity

Table 9		Drift Velocities	
Date = 15 NOV 72		Day Number = 320	
$\Sigma Kp = 24.33$		$F10.7 = 88.4$	
		$\bar{F}10.7 = 108.5$	
Local Time (hr:min)	Velocity (m/sec)		
10:00	50		
11:00	0		
12:00	-42		
13:00	-32		
14:00	30		
14:30	25		
15:00	-10		
16:00	-38		

Table 10 27 JUL 72 and 20 JUL 71,  
westward velocities

Table 9		Drift Velocities		Table 10		Drift Velocities	
Date = 15 NOV 72		Day Number = 320		Date = 27 JUL 72		Day Number = 209	
$\Sigma Kp = 24.33$		$F10.7 = 88.4$		$\Sigma Kp = 15.66$		$F10.7 = 123.4$	
		$\bar{F}10.7 = 108.5$				$\bar{F}10.7 = 127.7$	
Northward				Westward			
Local Time (hr:min)	Velocity (m/sec)	Local Time (hr:min)	Velocity (m/sec)				
10:00	50	02:00	-30				
11:00	0	04:00	-15				
12:00	-42	05:00	40				
13:00	-32	06:00	38				
14:00	30	07:00	37				
14:30	25	08:00	8				
15:00	-10	09:00	1				
16:00	-38	10:00	-3				
		11:00	-5				
		12:00	-6				
		13:00	-5				
Date = 27 JAN 72		Day Number = 27		Date = 20 JUL 71		Day Number = 201	
$\Sigma Kp = 24$		$F10.7 = 122.6$		$\Sigma Kp = 7$		$F10.7 = 115.0$	
		$\bar{F}10.7 = 127.0$				$\bar{F}10.7 = 111.1$	
11:00	-12	08:00	20				
11:30	-21	08:45	0				
12:00	-40	09:15	-25				
12:30	-40	10:00	-30				
13:30	40	11:00	-20				
14:00	30	12:00	-18				
14:30	22	13:00	-18				
15:00	10	14:00	-5				
15:30	25	15:00	20				
		16:00	32				
		17:00	37				
		18:00	40				

Table 11 6 DEC 72 and 16 NOV 72,  
northward velocities

Table 11 Date = 6 DEC 72 Day Number = 341 $\Sigma Kp = 5$ $F10.7 = 80.1$ $\bar{F}10.7 = 102.2$		Table 12 Date = 7 DEC 72 Day Number = 342 $\Sigma Kp = 18$ $F10.7 = 89.8$ $\bar{F}10.7 = 102.2$	
Northward		Northward	
Local Time (hr:min)	Velocity (m/sec)	Local Time (hr:min)	Velocity (m/sec)
10:00	-2	08:00	-5
11:00	-5	09:00	-12
12:00	-10	10:00	-3
13:00	-12	11:00	0
14:00	-18	12:00	-19
14:30	-16	13:00	-23
15:00	0	14:00	-23
15:30	0	15:00	-7
16:00	-12	15:30	0
17:00	-12	16:00	0

12

Table 11 Date = 16 NOV 72 Day Number = 321 $\Sigma Kp = 33.33$ $F10.7 = 91.6$ $\bar{F}10.7 = 108.5$		Table 12 Date = 24 MAR 72 Day Number = 84 $\Sigma Kp = 26.66$ $F10.7 = 127.4$ $\bar{F}10.7 = 127.7$	
Northward		Northward	
Local Time (hr:min)	Velocity (m/sec)	Local Time (hr:min)	Velocity (m/sec)
08:00	-26	07:00	-3
09:00	-15	07:30	-10
10:00	20	08:00	-12
11:00	35	09:00	-8
12:00	31	10:00	15
13:00	2	11:00	35
14:00	10	12:00	-6
15:00	0	13:00	28
16:00	-14	13:30	7
		14:00	-3
		15:00	10
		16:00	40

Table 13 27 FEB 73, north and westward velocities

Table 13 Drift Velocities			
Date = 27 FEB 73 Day Number = 58			
$\Sigma Kp = 37.33$ $F10.7 = 100.1$ $\bar{F}10.7 = 100.5$			
Northward		Westward	
Local Time (hr:min)	Velocity (m/sec)	Local Time (hr:min)	Velocity (m/sec)
10:43	14	10:55	-28
11:28	48	11:38	-38
13:33	140	13:01	-36
14:13	88	13:43	-22
14:54	78	14:23	-10
15:34	34	15:04	45
17:04	-21	15:49	32
17:46	21	16:30	41
		17:15	26
		18:01	67

Table 14 28 FEB 73, north and westward velocities

Table 14 Drift Velocities			
Date = 28 FEB 73 Day Number = 59 Σ Kp = 25.66 F10.7 = 102.9 F10.7 = 100.5			
Northward		Westward	
Local Time (hr:min)	Velocity (m/sec)	Local Time (hr:min)	Velocity (m/sec)
08:49	15	09:06	-13
09:45	19	11:33	-18
11:24	-8	12:12	-24
12:02	-10	13:28	1
13:10	3	14:23	21
14:05	-12	15:19	58
15:01	-16		

14

Table 15 2 JAN 73, northward velocities			
Date = 2 JAN 73 Day Number = 2 Σ Kp = 3 F10.7 = 98.2 F10.7 = 101.3			
Northward			
Local Time (hr:min)	Velocity (m/sec)		
09:00	9		
10:00	5		
11:00	-5		
12:00	-4		
13:00	1		
14:00	-5		
15:00	-3		
16:00	9		
17:00	-1		
18:00	-1		

Table 16 17 JUL 73, north and westward velocities

Northward		Westward	
Date = 17 JUL 73		Day Number = 198	
Local Time (hr:min)		Drift Velocities	
		$\Sigma Kp = 11.66$ F10.7 = 75.6 FM10.7 = 86.1	
Local Time (hr:min)	Velocity (m/sec)	Local Time (hr:min)	Velocity (m/sec)
11:30	16	11:14	-5
12:14	12	12:34	25
13:37	-12	13:17	26
14:17	-12	14:36	37
15:34	33	15:14	72
16:20	12	16:45	56
17:49	32	17:28	80
18:37	27	18:57	66
20:05	14	19:43	48
20:45	31	21:04	47
22:05	20	21:46	45
22:43	47	23:04	99
		23:47	94



Table 17 18 JUL 73, north and westward velocities

Table 17		Drift Velocities	
Date = 18 JUL 73	Day Number = 199	$\Sigma Kp = 12$	$F10.7 = 80.9$ $FM10.7 = 86.1$
Northward		Westward	
Local Time (hr:min)	Velocity (m/sec)	Local Time (hr:min)	Velocity (m/sec)
00:04	44	01:01	64
00:43	-4	02:40	15
02:22	38	03:18	4
05:56	16	04:58	-18
06:38	42	05:38	36
07:55	-3	06:57	57
08:43	14	07:36	25
10:01	14	09:03	19
10:45	9	09:41	22
12:03	-6	11:05	4
14:03	-7	11:43	28
14:44	-9	13:04	25
16:26	-8	13:44	-2
17:05	11	15:24	35
19:06	14	16:08	45
20:24	22	17:23	42
21:02	25	18:00	43
23:12	-1	19:25	38
		20:06	42
		21:50	28
		22:29	20

Table 18 19 JUL 73, north and westward velocities

Table 18		Drift Velocities	
Date = 19 JUL 73	Day Number = 200	$\Sigma Kp = 18.66$	$F10.7 = 79.0$ $FM10.7 = 86.1$
Northward		Westward	
Local Time (hr:min)	Velocity (m/sec)	Local Time (hr:min)	Velocity (m/sec)
01:06	21	00:08	59
01:44	-35	00:47	-25
02:44	23	02:03	-62
04:04	-105	03:08	7
04:44	-40	03:46	-94
06:34	30	05:02	8
07:44	46	05:42	27
09:01	0	08:03	63
09:42	8	08:43	28
10:57	2	10:02	-11
11:46	6	10:39	-9
13:03	-5	12:05	5
15:02	16	12:43	-14
15:39	12	14:07	0
		14:44	10
		15:57	11

Table 19 7 AUG 73, north and westward velocities

Northward		Westward	
Table 19		Drift Velocities	
Date = 7 AUG 73	Day Number = 219	$\Sigma Kp = 16.66$	$F10.7 = 88.3$ $FM10.7 = 90.8$
Local Time (hr:min)	Velocity (m/sec)	Local Time (hr:min)	Velocity (m/sec)
12:04	-1	11:45	-1
12:44	6	13:10	34
14:11	-13	13:53	13
15:12	-12	14:54	26
16:58	-4	17:15	17
18:13	0	17:53	48
19:35	2	19:54	83
20:51	25	20:33	58
21:40	64	21:58	61
22:41	139	22:59	28

Table 20 8 AUG 73, north and westward velocities

Table 20		Drift Velocities		FM10.7 = 90.8	
Date = 8 AUG 73	Day Number = 220	$\Sigma Kp = 17$	F10.7 = 85.1		
Northward		Westward			
Local Time (hr:min)	Velocity (m/sec)	Local Time (hr:min)	Velocity (m/sec)		
00:43	28	01:03	25		
02:52	25	03:11	-18		
04:53	-6	03:52	-45		
06:13	64	05:11	40		
06:54	18	05:55	-3		
08:13	24	07:14	11		
08:59	-11	07:52	-45		
10:15	-20	09:18	-15		
10:53	-23	09:57	-34		
12:12	-4	11:52	-1		
12:55	9	13:17	34		
14:13	1	13:55	13		
14:52	25	15:11	26		

Table 21 12 FEB 74, north and westward velocities

20

Table 21 Drift Velocities			
Date = 12 FEB 74 Day Number = 43			
$\Sigma Kp = 35.66$ F10.7 = 78.5 F10.7 = 81.1			
Northward		Westward	
Local Time (hr:min)	Velocity (m/sec)	Local Time (hr:min)	Velocity (m/sec)
14:21	2	14:31	8
15:19	16	15:00	11
15:55	-36	16:07	7
16:50	2	16:38	38
17:20	-8	17:31	45
18:13	-2	18:01	51
20:34	19	19:53	44
21:04	49	21:14	23
22:53	10	22:35	17
23:35	-6		

Table 22 13 FEB 74, north and westward velocities

Table 22 Drift Velocities			
Date = 13 FEB 74 Day Number = 43			
$\Sigma Kp = 27.33$ F10.7 = 79.3 F10.7 = 81.1			
Northward		Westward	
Local Time (hr:min)	Velocity (m/sec)	Local Time (hr:min)	Velocity (m/sec)
07:06	11	06:47	7
08:33	18	08:16	26
09:02	28	09:15	9
10:02	31	09:51	-5
10:37	7	10:48	5
11:35	7	11:22	13
12:08	29	12:19	-15
13:01	54	12:51	30
13:30	53	15:12	2
14:23	40	15:44	-15
14:54	13	16:47	31
15:55	8	17:20	33
16:37	-20	18:11	64
17:31	2	18:42	61
18:01	-25	19:42	-10
18:54	-12	20:12	8
20:22	80	21:19	-14
21:01	62		
22:17	67		
23:11	-1		

Table 23 16 APR 74, north and westward velocities

Table 23 Drift Velocities			
Date = 16 APR 74 Day Number = 106			
$\Sigma Kp = 7$ $F10.7 = 85.3$ $F10.7 = 114.2$			
Northward		Westward	
Local Time (hr:min)	Velocity (m/sec)	Local Time (hr:min)	Velocity (m/sec)
09:16	12	09:06	-44
09:47	21	09:57	-32
10:38	19	10:28	-27
11:08	15	11:17	-32
12:07	21	11:58	-22
12:36	-14	12:49	-17
13:28	-3	13:18	-21
13:58	-16	14:15	-8
15:16	-10	15:07	-5
15:45	-28	15:55	6
16:51	22	16:40	19
17:21	5	17:32	-1
18:13	-6	18:03	3
18:44	10	18:54	-17
19:35	-20	19:25	24
20:17	12	20:27	15
21:10	-18	21:50	-3
21:40	-12	22:20	-34
22:30	-26	23:14	-34
23:04	-14	23:54	-27
23:57	-30	00:44	-15
05:37	29	01:18	17
06:11	-13	02:10	-1
07:04	12	04:56	3
07:34	-8	05:26	58
08:21	6	06:21	18
		06:53	40
		07:43	16
		08:11	13

Table 24 15 JUL 74, north and westward velocities

Northward		Westward	
Date = 15 JUL 74		Drift Velocities	
Day Number = 196		ΣKp = 19 F10.7 = 82.8 FM10.7 = 92.5	
Local Time (hr:min)	Velocity (m/sec)	Local Time (hr:min)	Velocity (m/sec)
16:50	11	16:36	70
17:46	48	17:36	31
18:43	22	18:29	43
19:21	124	19:12	66
20:04	55	19:54	44
21:23	33	20:34	61
22:04	16	21:14	59
22:43	6	21:54	74
24:00	1	22:34	141
		23:21	105
		23:51	46



Table 25 16 JUL 74, north and westward velocities

Northward		Westward	
Date = 16 JUL 74		Day Number = 197	
Local Time (hr:min)		Drift Velocities	
		$\Sigma Kp = 17.33$ F10.7 = 88.4 FM10.7 = 92.5	
Local Time (hr:min)	Velocity (m/sec)	Local Time (hr:min)	Velocity (m/sec)
00:39	6	00:29	87
01:20	4	01:09	36
02:02	-59	01:52	-24
02:43	-55	06:14	24
06:54	32	06:43	20
08:43	30	07:53	21
09:39	22	08:32	2
10:30	-14	09:29	-3
12:00	-24	10:30	3
12:42	-26	12:00	12
14:00	2	13:00	20
15:00	14	14:00	18
16:00	11	15:00	25
17:00	7	16:00	42
18:00	-2	17:00	41
19:00	-2	18:00	12
20:00	10	19:00	8
21:00	12	20:00	44
22:00	6	21:00	36
22:42	21	22:00	50
		22:30	148

Table 26 17 JUL 74, north and westward velocities

Northward		Westward	
Date = 17 JUL 74		Drift Velocities	
Day Number = 198		$\Sigma Kp = 16.33$ F10.7 = 88.1 FM10.7 = 92.5	
Local Time (hr:min)	Velocity (m/sec)	Local Time (hr:min)	Velocity (m/sec)
00:21	-8	00:12	31
01:00	19	01:39	-6
01:30	-96	02:22	0
02:12	-17	03:03	-33
02:52	-24	03:44	-35
03:34	-27	04:25	-7
04:15	-39	09:36	26
08:40	41	10:00	20
09:36	8	11:00	4
10:00	-6	12:00	6
11:00	-8	13:00	2
12:00	0	14:00	12
13:00	1	15:00	4
14:00	14	16:00	22
15:00	-4	17:00	12
16:00	4	18:00	26
17:00	-2		
18:00	2		

Table 27 20 JUL 71

20 JUL 71

Upward Drifts		
Local Time (hr:min)	Velocity (m/sec) 300 km	375 km
00:03	-17.2	-12.2
00:29	-23.4	-20.5
00:57	-13.3	-16.1
01:24	-34.2	-28.6
01:51	-16.6	-14.4
02:44	-25.1	-15.5
03:48	-29.7	-10.1
04:14	2.8	24.9
04:41	14.5	33.7
05:08	16.5	38.7
05:35	1.8	23.5
06:02	9.7	14.9
06:28	-2.5	16.4
06:55	-7.4	5.1
07:21	-4.2	2.5
07:48	2.3	7.1
08:24	-11.0	0.9
08:51	-7.5	-9.7
09:17	-18.1	-17.5
09:48	-9.3	-6.6

20 JUL 71

Upward Drifts		
Local Time (hr:min)	Velocity (m/sec) 300 km	375 km
10:14	-10.1	-3.9
10:41	-22.6	-24.4
11:07	-13.5	-11.0
11:33	-14.9	-17.4
12:00	-13.5	-6.3
12:27	-9.5	-11.8
12:54	-16.0	12.7
13:21	-10.7	-8.4
13:57	-26.0	-23.6
14:31	-8.8	-2.5
15:05	-4.7	5.7
15:39	50.5	58.9
16:14	-11.3	-10.7
16:49	-6.9	-10.3
17:23	-4.1	-5.1
17:58	-11.4	-12.3
18:32	-14.9	-10.8

Table 28 27 JAN 72 and 30 JUN 72

27 JAN 72

Upward Drifts		
Local Time (hr:min)	Velocity (m/sec) 300 km	375 km
04:53	-14.1	-10.7
05:19	-22.0	-17.8
05:47	-28.1	-23.4
06:13	-23.3	- 6.7
06:39	-12.7	9.8
07:05	-21.6	4.8
07:30	16.5	1.3
07:57	-20.9	- 4.7
09:43	-35.8	-31.8
10:28	-20.0	13.9
11:09	-15.6	- 5.9
11:50	-21.8	-17.6
12:30	-24.6	-12.6
13:13	-25.9	-18.5
13:55	-17.8	- 8.8
14:35	-23.5	-23.5
15:15	-23.8	-19.0

30 JAN 72

Upward Drifts		
Local Time (hr:min)	Velocity (m/sec) 300 km	375 km
12:25	-18.2	-19.9
13:31	-19.8	-12.7
14:46	-14.9	- 9.9
16:02	-13.5	-10.9
17:20	- 3.4	-12.1
18:37	-17.6	-18.3
19:52	-18.5	- 8.0
21:12	-15.3	-15.4
22:27	-17.7	-15.4
23:51	-10.9	-10.9
01:07	-16.2	-12.5
01:45	-13.7	-16.2
02:22	- 8.1	- 3.9
03:00	-11.9	-15.0
03:37	- 6.9	- 9.2
04:55	-10.9	-10.1
06:10	-13.7	-17.8
07:26	- 6.6	- 5.8
08:51	-18.1	2.3
09:29	-29.1	-20.0
10:43	-38.0	-35.5
11:59	-19.5	-13.7

Table 29 30 MAY 72 and 6 SEP 72

30 MAY 72

6 SEPT 72

Upward Drifts		
Local Time (hr:min)	Velocity (m/sec) 300 km	375 km
09:17	-10.1	- 6.7
09:58	-23.9	- 9.6
10:50	-19.6	-11.9
11:30	-14.9	- 9.0
12:08	-24.0	-21.6
12:45	-19.2	- 1.2
13:25	-24.0	-21.9
14:04	-15.5	- 1.5
14:42	- 4.0	2.5
15:22	13.9	7.9
16:00	- 3.7	-17.0
16:39	-19.4	-17.0
17:17	-24.3	-13.2
17:55	- 3.1	- 7.1
18:33	-28.6	-30.1
19:16	-16.0	-12.8
20:09	-15.6	21.4
20:46	-17.6	- 8.1
21:24	-10.1	-16.5
22:01	-28.4	-30.6
22:38	-33.6	-17.0
23:17	-22.4	-11.1
23:55	-21.3	-14.7

Upward Drifts		
Local Time (hr:min)	Velocity (m/sec) 300 km	375 km
10:06	-20.8	- 3.8
11:27	-31.8	-16.7
12:43	-23.5	-17.8
13:58	-23.6	-12.0
15:21	-10.5	-12.5
16:38	-13.9	-13.4
17:17	-13.1	-11.9
18:06	-15.3	-11.0
18:48	-19.2	-20.2
19:29	-11.4	-22.4
20:07	-21.7	-29.7
20:46	-16.1	-11.7

Table 30 26 JUL 72 and 27 JUL 72  
26 JUL 72 27 JUL 72

Upward Drifts			Upward Drifts		
Local Time (hr:min)	300 km	Velocity (m/sec) 375 km	Local Time (hr:min)	300 km	Velocity (m/sec) 375 km
10:24	-12.9	-11.0	01:09	3.6	-12.2
11:02	-21.0	- 8.0	01:46	- 7.5	10.6
11:40	- 8.8	13.0	02:26	- 1.5	- 8.3
12:20	- 9.2	8.4	03:05	- 6.3	- 6.3
13:16	-35.1	-30.8	03:43	-22.3	-10.5
13:59	-30.2	-24.8	04:23	18.1	30.7
14:37	-34.6	-25.9	05:00	0.5	13.0
15:35	-17.9	- 7.8	05:43	-15.6	0.7
16:12	-16.4	- 9.9	06:20	-16.9	- 2.9
16:49	-16.1	-19.3	06:58	- 7.5	14.4
17:26	-22.8	-15.9	07:36	-10.1	- 3.4
18:06	-27.1	-22.8	08:20	-11.1	4.3
18:45	-25.5	-15.1	08:57	21.1	-12.3
19:23	- 4.0	- 0.3	09:43	-26.3	-12.2
20:02	-15.4	-17.2	10:14	-28.6	-16.8
20:40	-14.9	- 5.1	10:52	-32.0	-23.9
21:19	- 3.6	-10.4	11:29	-26.4	-18.0
21:56	- 7.1	-14.4	12:06	-29.7	-17.9
22:33	- 2.2	- 2.1	12:45	-16.1	-12.3
23:12	- 2.6	- 6.3	13:23	-14.7	- 9.1
23:55	20.5	13.9			

Table 31 15 NOV 72 and 16 NOV 72

15 NOV 72

16 NOV 72

Upward Drifts	
Local Time (hr:min)	Velocity (m/sec)
300 km	375 km
10:10	1.4
10:50	-21.8
11:27	-10.3
12:06	0.1
12:47	-18.5
13:39	-16.9
14:18	-25.1
14:56	- 7.0
15:33	- 8.8
18:26	-11.6
19:14	-14.3
19:53	-10.2
20:32	2.5
21:11	-19.5
21:49	-20.6
22:29	-15.7
22:48	-22.2
23:25	- 6.8

Upward Drifts	
Local Time (hr:min)	Velocity (m/sec)
300 km	375 km
00:06	20.4
00:45	-32.2
01:22	3.2
01:59	-22.5
02:38	- 8.8
03:53	14.2
04:31	-10.2
05:11	-16.3
05:49	-32.1
06:27	5.9
07:05	18.0
07:44	31.7
08:22	- 2.5
08:59	12.1
09:36	-20.0
10:13	-22.0
10:52	- 4.2
11:31	- 9.7
12:14	-23.1
12:53	-12.7
13:55	-25.6
14:32	-11.5
15:49	-12.7
16:28	-18.8

Table 32 6 DEC 72 and 7 DEC 72

6 DEC 72		7 DEC 72	
Upward Drifts		Upward Drifts	
Local Time (hr:min)	Velocity (m/sec) 300 km	Local Time (hr:min)	Velocity (m/sec) 300 km
09:25	-30.7	00:13	-26.7
01:03	-20.0	00:52	-6.5
10:46	4.1	01:29	-15.3
11:25	-20.9	02:06	-18.7
12:09	-39.7	02:43	-17.0
12:50	-33.0	03:20	-10.5
13:27	-21.6	03:57	-16.1
14:04	-25.9	05:18	-11.9
14:41	-32.9	06:00	-21.7
15:19	-28.1	06:37	-20.0
16:03	-32.3	07:14	-31.4
16:40	-29.9	08:10	-18.3
17:21	-31.2	08:49	-26.2
18:59	-23.2	09:26	-11.8
19:50	-15.8	10:04	-30.0
20:36	-13.8	10:42	-25.9
21:36	-2.6	11:20	-14.8
22:16	-14.1	11:57	-24.1
22:56	0.4	12:38	-18.7
23:36	-21.7	13:16	-35.7
		14:03	-6.6
		14:40	-27.7
		15:22	-18.9
		15:59	-24.3
			-33.8
			-13.0
			-19.3
			-15.5
			-11.8
			-12.7
			-15.5
			-18.7
			-34.0
			-5.1
			-19.2
			12.1
			0.3
			14.8
			-25.1
			-12.1
			-7.8
			-10.2
			-19.4
			-19.3
			1.5
			-15.2
			-7.4
			-16.8



Table 33 27 FEB 73 and 28 FEB 73

27 FEB 73

Upward Drifts		
Local Time (hr:min)	300 km	Velocity (m/sec) 375 km
10:27	-21.7	- 8.0
11:09	-41.4	-35.9
11:55	-21.1	- 7.9
13:16	-14.5	- 8.6
13:58	-22.2	- 9.7
14:38	-23.7	-13.1
15:19	-25.8	-14.4
16:04	-28.1	-21.7
16:45	-21.8	-29.3
17:30	-17.2	-12.9
18:25	-30.3	-22.2

28 FEB 73

Upward Drifts		
Local Time (hr:min)	300 km	Velocity (m/sec) 375 km
08:34	-37.9	-13.9
11:09	-20.8	- 8.8
11:47	-31.4	-17.6
12:26	-25.6	-14.3
13:50	-27.4	-18.3
14:46	-26.8	-10.5

Table 34 17 JUL 73 and 2 JAN 73

17 JUL 73

2 JAN 73

Upward Drifts		
Local Time (hr:min)	Velocity (m/sec) 300 km	Velocity (m/sec) 375 km
10:59	-25.1	-21.9
11:53	-35.0	-21.2
13:02	-16.3	-10.0
14:00	-31.7	-20.2
14:58	-25.1	-16.1
16:03	- 9.7	- 0.4
17:09	- 6.0	- 6.0
18:19	-13.9	- 9.6
19:28	-24.5	-23.9
20:28	-23.4	-20.5
21:28	-17.1	-15.7
22:27	-13.0	-17.1
23:32	-13.7	- 9.2

Upward Drifts		
Local Time (hr:min)	Velocity (m/sec) 300 km	Velocity (m/sec) 375 km
10:19	3.3	23.5
11:00	-33.1	-30.7
11:49	-14.8	-11.3
12:27	-33.5	-15.9
13:07	-24.8	- 7.1
13:53	-24.9	-30.4
14:31	-30.8	-33.9
15:09	-35.4	-32.6
15:48	-35.7	-21.3
16:26	-22.8	-15.8
17:04	-28.2	-23.3
17:44	-21.7	-25.7
18:25	-42.1	-49.3
19:21	-14.6	-21.8

Table 35 18 JUL 73 and 19 JUL 73

18 JUL 73

19 JUL 73

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Upward Drifts		
Local Time (hr:min)	Velocity (m/sec) 300 km	375 km
00:27	-21.8	-12.1
02:06	-29.7	-25.3
03:03	-28.6	-20.4
03:58	12.7	12.2
05:21	5.3	43.0
06:19	-32.2	-13.0
07:21	-18.8	-7.5
08:28	-10.5	-0.5
09:26	-26.6	-9.5
10:25	-33.3	-23.1
11:27	-28.5	-20.5
12:27	-13.5	-7.5
13:28	-16.1	-8.1
14:27	-12.1	2.1
15:47	-20.7	-4.7
16:49	-13.4	-10.2
17:45	-2.3	-0.1
18:42	-17.2	-17.6
19:51	-28.3	-36.0
20:48	-20.0	-15.4
22:15	-9.9	-12.6
23:35	-23.4	-22.1

Upward Drifts		
Local Time (hr:min)	Velocity (m/sec) 300 km	375 km
00:32	-5.9	-11.2
01:28	24.3	-2.3
02:28	-28.1	-40.3
03:31	-13.9	-4.0
04:28	38.4	58.5
05:28	-34.0	48.0
07:22	-3.2	2.5
08:26	-18.2	-7.9
09:26	-36.2	-20.8
10:24	-13.8	-9.1
11:30	-32.1	-22.6
12:28	-23.4	-11.3
13:31	-13.2	0.5
14:29	-22.4	-13.8
15:24	-17.8	-4.0

Table 36 7 AUG 73 7 A' C 73 and 8 AUG 73

7 AUG 73

8 AUG 73

Upward Drifts		
Local Time (hr:min)	Velocity (m/sec) 300 km	Velocity (m/sec) 375 km
11:27	- 2.0	- 1.6
12:28	-29.5	-17.3
13:34	-31.1	-10.8
14:37	-18.2	- 4.6
18:38	-20.6	- 9.2
19:17	-26.6	-24.5
20:16	-15.9	-14.0
21:19	-27.1	-25.6
22:22	-16.4	- 7.0
23:23	-10.3	-16.0

Upward Drifts		
Local Time (hr:min)	Velocity (m/sec) 300 km	Velocity (m/sec) 375 km
00:27	-19.0	-15.9
01:28	-24.7	-19.9
02:37	24.9	22.0
03:35	44.3	7.0
04:38	22.6	37.3
05:37	-31.1	- 5.4
06:38	-20.4	-18.7
07:36	-16.9	15.6
08:45	- 8.2	- 3.5
09:41	33.4	-13.6
10:38	-26.6	-14.1
11:37	-10.6	- 0.6
12:37	-14.8	- 2.1
13:40	-14.6	- 2.8
14:37	-24.1	- 9.1

Table 37 12 FEB 74 and 13 FEB 74  
12 FEB 74 13 FEB 74

Upward Drifts		
Local Time (hr:min)	300 km	375 km
13:57	-48.3	-52.2
14:45	-26.2	-21.0
15:37	-11.4	- 2.8
16:22	-39.4	-26.5
17:46	-43.0	-37.5
18:28	-33.6	-34.8
20:09	-29.4	-29.9
20:49	-26.0	-13.1
21:28	-26.2	-22.5
22:17	-67.0	-64.1
23:16	-43.4	-40.9

Upward Drifts		
Local Time (hr:min)	300 km	375 km
05:34	-41.3	-52.0
06:32	-49.8	- 0.7
07:49	-16.3	17.3
08:47	-34.1	-16.2
09:32	-42.2	-27.3
10:20	-21.3	-11.8
11:05	-11.6	7.3
11:51	-43.5	-29.3
12:36	-34.6	-36.4
13:14	-31.2	-17.3
13:55	-32.4	-23.8
14:38	-36.6	-28.1
15:28	-46.8	-36.1
16:20	-34.1	-25.0
17:05	-33.5	-18.9
17:45	-30.3	-34.7
18:26	-41.7	-41.1
19:12	-28.8	-27.3
19:57	-34.2	-30.7
20:43	-20.2	-24.7
21:41	-20.3	-25.7

Table 38 16 APR 74 and 17 APR 74  
16 APR 74 17 APR 74

Updrift Drifts			Updrift Drifts		
Local Time (hr:min)	Velocity (m/sec) 300 km	Velocity (m/sec) 375 km	Local Time (hr:min)	Velocity (m/sec) 300 km	Velocity (m/sec) 375 km
09:31	-20.2	-12.0	00:15	-16.7	-19.7
10:12	-24.0	-16.5	01:00	-17.2	-18.3
10:53	-18.0	-10.6	01:44	-26.2	-27.7
11:42	-18.7	-6.1	02:24	-16.1	-29.8
12:21	-20.6	-14.9	03:05	-19.8	-30.6
13:03	-17.9	-10.7	03:33	-24.9	-22.9
13:42	-21.7	-10.2	04:28	-12.2	-8.9
14:29	-17.6	-6.4	05:10	2.3	25.2
15:31	-16.4	-3.8	05:54	-11.3	4.4
16:23	-12.7	-6.2	06:36	-17.1	4.2
17:06	-15.2	-9.9	07:19	-10.0	-8.7
17:21	-13.6	0.0	08:35	-19.7	-12.8
17:48	-18.0	-15.4			
18:28	-27.5	-20.2			
19:10	-18.8	-17.1			
20:01	-14.3	-16.6			
20:45	-27.5	-21.3			
21:24	-10.9	-7.8			
22:05	-18.5	-24.1			
22:46	-11.1	-6.2			
23:29	-20.6	-19.9			

Table 39 15 JUL 74 and 16 JUL 74

15 JUL 74

Upward Drifts		
Local Time (hr:min)	Velocity (m/sec) 300 km	375 km
17:16	-13.6	-14.3
18:00	-16.9	- 5.2
18:57	-13.2	-20.2
19:38	-13.9	-15.0
20:18	-21.3	- 9.2
20:58	-24.3	-17.1
21:38	-19.8	-19.3
22:19	-15.9	-19.0
22:57	-24.0	-23.7
23:36	-29.5	-16.2

16 JUL 74

Upward Drifts		
Local Time (hr:min)	Velocity (m/sec) 300 km	375 km
00:14	-43.3	-33.4
00:53	-30.6	-21.6
01:36	-13.6	-12.9
02:16	37.0	11.5
02:57	-31.9	-45.6
06:29	-24.3	- 7.8
07:19	- 5.9	- 0.6
08:08	-11.8	- 7.6
23:57	4.0	- 8.6

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